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CLAIMS

What is claimed is:

1. An optical system comprising:
an optical pulse source generating an input optical pulse stream;
a controllable optical delay structure coupled to the optical pulse source, the optical delay structure providing a plurality of output optical pulse streams, each output optical pulse stream having a controllable time delay relative to the input optical pulse stream; and
a control means for controlling the controllable time delay of each output optical pulse stream.

2. The optical system according to Claim 1, further comprising an array of optical apertures, each optical aperture in the array receiving one output optical pulse stream from the plurality of output optical pulse streams.

3. The optical system according to Claim 2, wherein the array of optical apertures comprises an array of steerable optical apertures.

4. The optical system according to Claim 1, further comprising a wavefront compensator integrated with the array of optical apertures.

5. The optical system according to Claim 1, wherein the optical pulse source comprises:
an optical pulse generator generating a stream of unmodulated optical pulses;
an information signal source; and

an optical modulator modulating the unmodulated optical pulses with an information signal from the information signal source to produce the input optical pulse stream.

6. The optical system according to Claim 5, wherein the optical pulse generator comprises a laser.

7. The optical system according to Claim 1, wherein the controllable optical delay structure comprises:

a layer of electro-optically active material having a proximal end and a distal end;

means for applying voltage across the layer of electro-optically active material;

means for coupling the input optical pulse stream into the proximal end of the layer of electro-optic material; and

a plurality of tapped output couplers, said tapped output couplers disposed in a linear direction from the proximal end to the distal end of the layer of electro-optically active material, each tapped output coupler of the plurality of tapped output couplers disposed in an increasing distance from the proximal end to the distal end of the electro-optically active material,

wherein the control means controls the means for applying voltage.

8. The optical system according to Claim 7, wherein the layer of electro-optically active material comprises an optical bulk substrate structure having a specified thickness, the bulk substrate structure having an upper internally reflective surface and a lower internally reflective surface, wherein the input optical pulse stream propagates from the proximal end to the distal end by successively reflecting from one internally reflective

surface to the other, and the controllable time delay being proportional to the specified thickness and the distance between each tapped output coupler.

9. The optical system according to Claim 7, wherein the layer of electro-optically active material comprises a guided-wave electro-optic device having an upper surface and a lower surface generally parallel to each other, wherein the input optical pulse stream propagates from the proximal end to the distal end by moving in a direction generally parallel to the surfaces, and the controllable time delay being proportional to the distance between each tapped output coupler.

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10. The optical system according to Claim 7 wherein the means for applying voltage comprises:

a first electrode located on a first side of the layer of electro-optic material;

a second electrode located on a second side of the layer of electro-optic material opposite the first side,

and wherein the control means comprises a voltage source connected to the first electrode and to the second electrode.

11. The optical system according to Claim 7 wherein the means for applying voltage comprises:

a first plurality of electrodes located on a first side of the layer of electro-optic material;

a second plurality of electrodes located on a second side of the layer of electro-optic material opposite the first side, each electrode in the second plurality of electrodes paired with a corresponding electrode in the first plurality of electrodes to form an electrode pair,

and wherein the control means comprises a plurality of separately controllable voltage sources, each voltage source in the plurality of voltage sources connected to one or more electrode pairs.

12. The optical system according to Claim 7 wherein each tapped output coupler in said plurality of tapped output couplers is located equidistant from adjoining tapped output couplers.

13. The optical system according to Claim 7 wherein said plurality of tapped output couplers comprises a plurality of output gratings.

14. The optical system according to Claim 7 wherein each tapped output coupler in said plurality of tapped output couplers has a diffraction efficiency, said diffraction efficiency increasing with the distance that each tapped output coupler is disposed from said proximal end.

15. The optical system according to Claim 1, wherein the controllable optical delay structure comprises:

a layer of electro-optically active material having a proximal edge, a distal edge, a leading edge, and a trailing edge, wherein a first line having the proximal edge and the distal edge as its ends is perpendicular to a second line having the leading edge and the trailing edge as its ends;

means for applying voltage across the layer of electro-optic material;

means for coupling the input optical pulse stream into the proximal edge of the layer of electro-optically active material; and

a plurality of lines of tapped output couplers, the tapped output couplers in each line disposed in a linear direction from the proximal edge to the distal edge of the layer, each tapped coupler in each line of tapped couplers disposed in an increasing distance from the proximal edge to the distal edge, and each line of tapped output couplers disposed in a linear direction from the leading edge to the trailing edge of the layer,

wherein the control means controls the means for applying voltage.

16. The optical system according to Claim 15, wherein the layer of electro-optically active material comprises an optical bulk substrate structure having a specified thickness, the bulk substrate structure having an upper internally reflective surface and a lower internally reflective surface, wherein the input optical pulse stream is split into a plurality of parallel input optical pulse streams, each parallel input optical pulse stream moving from the proximal edge to the distal edge of the layer in a line defined by a separate one of the plurality of lines of tapped output couplers by successively reflecting between internally reflective surfaces, and the controllable time delay being proportional to the specified thickness and the distance between each tapped output coupler.

17. The optical system according to Claim 15, wherein the layer of electro-optically active material comprises a guided-wave electro-optic device having an upper surface and a lower surface generally parallel to each other, wherein the input optical pulse stream is split into a plurality of parallel input optical pulse streams, each parallel input optical pulse stream moving from the proximal edge to the distal edge of the layer by moving in a direction defined by a separate one of the plurality of lines of tapped output couplers and generally parallel to the surfaces, and the controllable time delay being proportional to

the distance between each tapped output coupler in the separate line of tapped output couplers.

18. The optical system according to Claim 15 wherein the means for applying voltage comprises:

a plurality of lines of electrodes located on a first side of the layer of electro-optically active material; and

a common electrode located on a second side of the layer of electro-optically active material opposite the first side,

wherein said plurality of lines of electrodes are disposed generally parallel and adjacent to the lines of tapped output couplers and wherein the control means comprises voltage sources connected between each line of electrodes in the plurality of lines of electrodes and the common electrode.

19. The optical system according to Claim 15 wherein the means for applying voltage comprises:

a matrix of individually addressable electrodes located on a first side of the layer of electro-optically active material, the electrodes separated from one another in two perpendicular directions; and

a common electrode located on a second side of the layer of electro-optic material opposite the first side,

wherein the control means comprises voltage sources connected between each individually addressable electrode in the matrix of individually addressable electrodes and the common electrode.

20. The optical system according to Claim 15 wherein each tapped output coupler in each line of tapped output couplers is located equidistant from adjoining tapped output couplers and each line of tapped output couplers is located equidistant from adjoining lines of tapped output couplers.

21. The optical system according to Claim 15 wherein each tapped output coupler comprises an output grating.

22. The optical system according to Claim 15 wherein each tapped output coupler has a diffraction efficiency, said diffraction efficiency increasing with the distance that each tapped output coupler is disposed from said proximal end.

23. A method for generating multiple optical pulse streams with controllable time delays comprising the steps of:

providing an optical pulse stream;

coupling the optical pulse stream into a controllable optical delay structure, the optical delay structure providing a plurality of delayed optical pulse streams, each delayed optical pulse stream having a controllable time delay relative to the input optical pulse stream; and

controlling the delay of each delayed optical pulse stream.

24. The method according to Claim 23, wherein the step of coupling the optical pulse stream into a controllable optical delay structure comprises:

coupling the optical pulse stream into a layer of electro-optically active material, the layer of electro-optically active material having multiple output ports disposed in a longitudinal direction;

directing said optical pulse stream in a longitudinal direction in the layer; and

coupling a portion of the optical pulse stream out of the layer at each output port to create the delayed optical pulse stream transmitted at each optical port,

and the step of controlling the delay of each output optical pulse stream comprises the steps of:

applying voltage across said layer of electro-optically active material; and

controlling the voltage to control an amount of delay provided to each delayed optical pulse stream.

25. The method according to Claim 24, wherein the layer of electro-optically active material comprises an optical bulk substrate structure having a specified thickness, the bulk substrate structure having an upper internally reflective surface and a lower internally reflective surface wherein the optical pulse stream propagates in the longitudinal direction of the layer by successively reflecting between the internally reflective surfaces.

26. The method according to Claim 24, wherein the layer of electro-optically active material comprises a guided-wave electro-optic device having an upper surface and a lower surface generally parallel to each other, wherein the optical pulse stream propagates in the longitudinal direction of the layer in a direction generally parallel to the surfaces.

27. The method according to Claim 24 wherein said each output port of said multiple output ports is located equidistantly from adjoining output ports.

28. The method according to Claim 23, wherein the step of coupling the optical pulse stream into a controllable optical delay structure comprises:

splitting the optical pulse stream into a plurality of parallel optical pulse streams;

coupling the optical pulse stream into a layer of electro-optically active material, the layer of electro-optically active material having a plurality of lines of output ports disposed laterally and parallel to each other across the layer and each line of output ports having multiple output ports disposed in a longitudinal direction across the layer;

directing the parallel optical pulse streams into the layer of electro-optically active material, each parallel optical pulse stream directed towards a corresponding line of output ports; and

coupling a portion of each parallel optical pulse stream out of the layer at each output port in the corresponding line of output ports to create the delayed optical pulse stream transmitted at each optical port,

and the step of controlling the delay of each delayed optical pulse stream comprises the steps of:

applying a plurality of voltages across said layer of electro-optically active material, each voltage corresponding to a line of output ports and applied in the vicinity of the corresponding line of output ports; and

controlling each voltage to control an amount of delay provided to each delayed optical pulse stream.

29. The method according to Claim 28, wherein the layer of electro-optically active material comprises a optical bulk substrate structure having a specified thickness, the bulk substrate structure having an upper internally reflective surface and a lower internally reflective surface, wherein the optical pulse stream propagates in the longitudinal direction of the layer by successively reflecting between the internally reflective surfaces.

30. The method according to Claim 28, wherein the layer of electro-optically active material comprises a guided-wave electro-optic layer having an upper surface and a lower surface generally parallel to each other, wherein the optical pulse stream propagates in the longitudinal direction of the layer in a direction generally parallel to the surfaces.

31. An optical beam steering device comprising:

at least one layer of electro-optically active material, the at least one layer of electro-optically active material having a proximal end and a distal end;

means for applying a voltage across the at least one layer;

means for coupling an optical signal into the proximal end of the at least one layer;

a plurality of tapped output couplers providing optical beam outputs, the tapped output couplers disposed on the at least one layer in a linear direction from said proximal end to said distal end, each tapped output coupler of the plurality of tapped output couplers disposed in an increasing distance from the proximal end;

an array of optical apertures, each optical aperture in the array of optical apertures receiving an optical beam output from a corresponding one tapped output coupler of the plurality of tapped output couplers.

32. The optical beam steering device of Claim 31, wherein the means for applying a voltage across the at least one layer comprises:

a first electrode located on a first side of the at least one layer;

a second electrode located on a second side of the at least one layer opposite the first side; and

a controllable voltage source connected to the first electrode and the second electrode, the voltage source generating a controllable electric field between the first electrode

and the second electrode when the voltage source is controlled to generate a voltage.

33. The optical beam steering device of Claim 31, wherein the means for applying a voltage across the at least one layer comprises:

a plurality of first electrode regions located on a first side of the at least one layer;

a plurality of second electrode regions located on a second side of the at least one layer opposite the first side; and

a plurality of controllable voltage sources, each voltage source connected to a corresponding one first electrode region of the plurality of first electrode regions and to a corresponding one second electrode region of the plurality of second electrode regions, each voltage source generating a controllable electric field between the corresponding first electrode region and the corresponding second electrode region when the corresponding voltage source is controlled to generate a voltage.

34. The optical beam steering device of Claim 31, wherein the means for coupling an optical signal into the proximal end of the at least one layer comprises an input optical grating disposed at the proximal end of the at least one layer.

35. The optical beam steering device of Claim 31, wherein the means for coupling an optical signal into the proximal end of the at least one layer comprises an optical prism disposed at the proximal end of the at least one layer.

36. The optical beam steering device of Claim 31, further comprising means for compensating for fixed delays, said means disposed between the tapped output couplers and the array of optical apertures, said means applying a fixed delay to each optical beam output, said

fixed delay inversely proportional to the distance from each tapped output coupler to the proximal end.

37. The optical beam steering device of Claim 36, wherein said means for compensating comprises an optical prism.

38. The optical beam steering device of Claim 31, wherein tapped output couplers are disposed in several lines of couplers on the at least one layer of electro-optically active material, each line of couplers comprising a plurality of tapped output couplers in a linear direction from the proximal end to the distal end, and the lines of couplers disposed parallel to each other on the at least one layer, and wherein the means for coupling an optical signal into the proximal end of the at least one layer couples the optical signal into each line of couplers.

39. The optical beam steering device of Claim 31, wherein the at least one layer of electro-optically active material comprises at least one layer of liquid crystal material.

40. A method of optical beam steering comprising the steps of:

coupling an input optical beam into at least one layer of electro-optically active material, the at least one layer having a plurality of optical output ports disposed in a longitudinal direction on one side of the at least one layer, each optical output port of the plurality of optical output ports being disposed in an increasing distance from a proximal end of the at least one layer to a distal end of the at least one layer;

directing the input optical beam into the at least one layer in the longitudinal direction of the plurality of optical output ports;

coupling a portion of the input optical beam out of the at least one layer at each output port to transmit a delayed optical beam from each output port, the delayed optical beam from each output port having a controllable delay in relation to the input optical beam;

applying an electric field across the at least one layer;

controlling the electric field to control the delay in the delayed optical beam from each output port; and

directing the delayed optical beam from each output port to an optical beam steering array.

41. The method of optical beam steering according to Claim 40, wherein the step of applying an electrical field comprises:

providing a first electrode on a first side of the at least one layer;

providing a second electrode on a second side of the at least one layer, the second side being opposite the first side; and

connecting a voltage source to the first electrode and the second electrode, and

wherein the step of controlling the electric field comprises controlling the voltage source.

42. The method of optical beam steering according to Claim 40, wherein the step of applying an electrical field comprises:

providing a plurality of first electrodes on a first side of the at least one layer;

providing a plurality of second electrodes on a second side of the at least one layer, the second side being opposite the first side; and

connecting a plurality of voltage sources to the plurality of first electrodes and second electrodes, each voltage source connected to a corresponding one first electrode of

the plurality of first electrodes and a corresponding one second electrode of the plurality of second electrodes,

wherein the step of controlling the electric field comprises separately controlling the voltage sources.

43. The method of optical beam steering according to Claim 40, wherein the step of directing each delayed optical beam to an optical beam steering array comprises:

applying a separate fixed delay to the delayed optical beam from each output port, the fixed delay inversely proportional to the distance from the output port to the proximal end of the at least one layer;

directing the delayed optical beam with the separate fixed delay from each output port to the optical beam steering array.